

Appendix 1

Russian State Committee for Construction
Research Institute of Concrete and Reinforced Concrete
Test results of crushed limestone
Fraction 3-10 mm

1. Results of sieve analysis

The 5kg mass sample was dried to the constant weight and was tested according to Russian standard GOST 8269.0-97. Results of test are presented in the Table 1.

Table 1

	Dimensions of Square Openings (mm)				
	12.50	10.00	5.00	2.50	under 2.50
Sieve residue (%)	0.75	0.75	64.00	25.50	9.00
Total remains (%)	0.75	1.50	65.50	91.00	100.00

2. Determination of compressive strength

Compressive strength of crushed limestone was estimated by the compress in the 150 mm diameter cylinder according to Russian standard GOST 8269.0, item 4.8. Results of test are presented in the Table 2.

Table 2

Sample number	Mass before test (m, kg)	Mass after test (m1, kg)	Loss of weight (%)
1	3.24	2.69	17
2	3.18	2.64	17

According to Russian building code this loss of weight corresponds to compressive strength of coarse aggregate equal to 600 kgf/ cm² (near 8500 psi). Limestone screenings is estimated as Grade 600 in terms of compressive strength.

3. Content of grains less than 0.16mm and clay particles made up 3.5 %.
4. Water-adsorption of sample is equal to 10%,
5. Specific gravity is equal to 2.46 g/cm³.
6. Bulk density is equal to 1390 kg/m³, volume of voids is estimated as 43%.

7. Frost resistance of crushed limestone sample was determined by the test of this sample in the solution of sodium sulfate with the subsequent drying. The lost of mass after 10 cycles made up 10%. According to Russian building code frost resistance of this crushed limestone sample is estimated as Grade F50.

8. Determination of chemical activity of aggregate. This activity is defined as availability of minerals with the silica dissolution in alkali. Content of dissoluble silica in crushed limestone made up 21 milliliter per liter.

Fraction 2-5 mm

1. Sieve analysis of this fraction as a fine aggregate was provided according to Russian building code GOST 8735-88. Residue on the sieve with the 5-mm square opening made up 20,5 % of mass of sample. Sieve analysis of part of sample finer than 5mm is presented in the Table 3.

Table 3

	Dimensions of Square Openings (mm)					
	2.50	1.25	0.63	0.315	0.16	under 0.16
Sieve residue (%)	87.50	11.00	0.50	-	-	1
Total remains (%)	87.50	98.50	99.00	99.00	99.00	100

2.Determination of crushing strength

Crushing strength of limestone was estimated by the compress in the 150 mm-diameter cylinder according to Russian standard GOST8269.0, item 4.8. Results of test are presented in the Table 4.

Table 4

Sample number	Mass before test (m, kg)	Mass after test (m1, kg)	Loss of weight (%)
1	3.09	2.57	17
2	3.11	2.60	16

According to Russian building code this loss of wight corresponds to compressive strength of coarse aggregate equal to 600 kgf/ cm² (near 8500 psi). Limestone screenings is estimated as Grade 600 in terms of compressive strength.

3. Content of grains less than 0.16mm and clay particles made up 1%.

4. Water-adsorption of sample is equal to 9%,
5. Specific gravity is equal to 2.42 g/cm³.
6. Bulk density is equal to 1330 kg/m³, volume of voids is estimated as 45%.
7. Frost resistance of sample was determined by the test of this sample in the solution of sodium sulfate with the subsequent drying. The loss of mass after 10 cycles made up 7%. According to Russian building code frost resistance of this crushed limestone sample is estimated as Grade F50.
8. Determination of chemical activity of aggregate. This activity is defined as availability of minerals with the silica dissolution in alkali. Content of dissoluble silica in limestone screenings made up 19 milliliter per liter.

Estimations of possibilities of the use small sizes crushed limestone as a coarse aggregate for normal concrete

To estimate possibility of use of small sizes crushed limestone as a coarse aggregate of normal concrete standard cubes 10x10x10 cm were performed with the use of portland cement Brand 500-DO-N of Oskol cement plant. According to Russian building practice of production of precast concrete cubes were subjected by the standard steam-curing according to next pattern; 3+3+6+4, i.e. 3 hr conditioning, 3 hr of the temperature rise to 80 C, 6 hr isothermal warming and 4 hr cooling. 1-day compressive strength of steam-cured concrete makes up 60-65% of 28-day strength of this concrete. 28-day compressive strength of steam-cured concrete makes up 90% of 28-day strength of concrete of natural maturing. Composition of concrete and test results of compressive strength of concrete brought to the standard European cube 15x15x15 cm and corresponding estimations of cylindrical strength (psi) are presented in the Table 5. Concrete mixes number 1, 3, 5 were made with lime crushed stone defined as a Russian fraction 3-10 mm (Table1) as a coarse aggregate, mixes number 2, 4, 6 were made with lime crushed stone defined as a Russian fraction 3-10 mm (Table2) as a coarse aggregate.

Table 5.

Number	Composition of ready-mixed concrete (kg/m ³)				Density Of the mix (kg/m ³)	Slump (cm)	Cubic compressive strength MPa	
	Cement	Sand	Coarse aggregate	Water/ cement ratio			1 day	28 days
1	198	751	1068	1.05	2225	6.5	5.8	10.0
2	197	740	1066	1.05	2210	7.0	4.8	8.0
3	347	596	1091	0.61	2245	8.0	19.4	29.0
4	350	580	1100	0.60	2240	8.5	17.9	28.3
5	498	478	1075	0.43	2265	7.5	37.1	42.0
6	500	483	1060	0.42	2255	9.0	31.1	38.4

As can be seen from the Table 5, compressive strength of concrete with researched lime crushed stone (fractions 3-10 and 2-5) as a coarse aggregate can correspond to Class B30 maximum (GOST2663-91).